

Remarks

In view of the above amendments and the following remarks, reconsideration of the outstanding office action is respectfully requested. Support for the amendments to claims 28 and 31 is found on page 5, lines 30–32, page 10, lines 4–9 (describing recovery of acid etched particles by filtering or centrifuging), page 12, lines 28–32 (describing dispersion of powders prior to etching), and page 32, lines 25–28.

The rejection of claims 28–33 under 35 U.S.C. § 102(b) for anticipation by Seraphin et al., “Influence of Nanostructure Size on the Luminescence Behavior of Silicon Nanoparticle Thin Films,” *J. Mater. Res.* 12(12):3386–3392 (1997) (“Seraphin”) is respectfully traversed.

Seraphin describes the effect of particle size and quantum confinement on the luminescence properties of nanoscale silicon thin films. Thin films of agglomerated silicon nanoparticles deposited onto Teflon substrates were oxidized, *inter alia*, chemically to reduce the silicon core dimensions, resulting in a shift of the luminescence emission peak to shorter wavelengths. Removal of the oxide using HF resulted in further blueshifting of the luminescence, as did subsequent reoxidation in air and using nitric acid. A blueshift was also observed in thin films etched with a HF/nitric acid/water solution.

Claims 28–30 relate to a process for altering photoluminescence of free silicon nanoparticles by acid etching the free silicon nanoparticles under conditions effective to produce photoluminescent free silicon nanoparticles. Claims 31–33 relate to a process for stabilizing photoluminescence of free silicon nanoparticles by treating the photoluminescent free silicon nanoparticles with an oxidizer under conditions effective to achieve particle surface oxidation. Since Seraphin’s methods are not carried out with free silicon nanoparticles, as required by claims 28–33, but rather on films of agglomerated silicon nanoparticles, the rejection based on this reference is improper and should be withdrawn.

The rejection of claim 36 under 35 U.S.C. § 102(b) for anticipation by Bocarsly, “Surface – Chemical Control of Optical Quenching Process at Porous Silicon Interfaces: Generation of a Stable-selective Sulfur-dioxide Sensor,” Abstract of Paper presented in ACS National Meetings (2000) (“Bocarsly”) is respectfully traversed.

Bocarsly teaches that, “*once formed*, the Si/SiO_x interface [on oxidized silicon nanoparticles] can be stabilized *even in the presence of water* at elevated temp[eratures] by modification with a silylfluorocarbon” (emphasis added).

Claim 36 relates to a process for stabilizing photoluminescence of silicon nanoparticles by treating photoluminescent silicon nanoparticles to produce photoluminescent silicon nanoparticles having a Si-OH terminated surface and treating the Si-OH surface-terminated nanoparticles to achieve particle surface silanization.

The U.S. Patent and Trademark Office (“PTO”) states that Bocarsly teaches forming the Si/SiO_x interface in water, which provides a Si-OH terminated surface on the nanoparticles, and which, in turn, is modified with a silylfluorocarbon to provide particle surface silanization. Applicants respectfully disagree. Bocarsly makes clear that the silicon particles are exposed to water *after* the Si/SiO_x interface is formed—the interface is not formed in water. Indeed, it seems that the interface is not even exposed to water until after modification with the silylfluorocarbon. Thus, Bocarsly fails to disclose producing photoluminescent silicon nanoparticles having a Si-OH terminated surface (let alone treating Si-OH surface-terminated nanoparticles to achieve particle surface silanization), as required by claim 36. Accordingly, the anticipation rejection of claim 36 by Bocarsly is improper and should be withdrawn.

The rejection of claim 35 under 35 U.S.C. § 102(e) for anticipation by U.S. Patent No. 6,846,565 to Korgel et al. (“Korgel”) is respectfully traversed.

Korgel relates to methods of producing nanoparticles by reacting an organometallic precursor in the presence of a capping agent.

Claim 35 relates to a process for stabilizing photoluminescence of silicon nanoparticles by treating photoluminescent silicon nanoparticles to produce photoluminescent silicon nanoparticles having a Si-H terminated surface and treating the Si-H surface-terminated nanoparticles to achieve particle surface hydrosilylation. The PTO’s position is that Korgel’s method would create Si-H terminated nanoparticles by hydrogen bonding, which are then capped by hydrosilyl ligand. Applicants respectfully disagree.

First, Korgel does not teach producing Si-H surface terminated silicon nanoparticles. The PTO has relied on the following language in Korgel for teaching Si-H surface termination:

The capping agent may interact with an organometallic precursor during formation of the nanoparticle to assist in controlling the growth of the particle. The capping agent may bond covalently to the particle surface, or stick through weak interactions, such as hydrogen bonding.

See column 8, lines 50–54. According to the PTO, Si-H terminated surfaces “are created by the hydrogen bonding.” The cited language clearly refers to interactions between the capping agent and the particle surface. As used in this context, one of ordinary skill in the art would have understood Korgel to be referring to “hydrogen bonding” in its traditional sense, not to bonds between silicon and hydrogen. *See* Declaration of Mark T. Swihart, Ph.D. ¶ 5 (“Swihart Decl.”) (attached hereto as Exhibit 1). That is, when hydrogen is attached to a strongly electronegative atom (usually oxygen or nitrogen), it will strongly interact with other electronegative atoms. *Id.* This would most likely occur in the context of silicon nanoparticles if there are -OH groups on the particle surface that can interact with other -OH groups in solution (in water, alcohols, etc.). *Id.* This is not related to what occurs during hydrosilylation of the silicon nanoparticles as carried out in the present invention. *Id.* During hydrosilylation, a hydrocarbon (which cannot participate in hydrogen bonding) reacts with an Si-H bond (which also cannot participate in hydrogen bonding). *Id.*

In general, the long list of molecules Korgel provides as potential capping agents will not react with hydrogen terminated silicon nanoparticles. Swihart Decl. ¶ 6. Only a small subset (alkenes, alkynes, perhaps some others) will do so. *Id.* The Korgel patent does not give any description of the reactions believed to lead to the capping of particles by alkenes or alkynes during synthesis, let alone teach that such capping is carried out by hydrosilylation. *Id.* An alkene or alkyne capping agent would not participate in hydrogen bonding, because it does not contain electronegative atoms (like O or N). Swihart Decl. ¶ 7. Hydrogen atoms on a hydrogen-terminated silicon surface also would not participate in hydrogen bonding. *Id.* Hydrogen atoms in -OH groups on an -OH terminated silicon surface would be expected to participate in hydrogen bonding, but that is not relevant to hydrosilylation, which will not occur on -OH terminated surfaces. *Id.* Thus, the cited language is inapposite to the present claims—i.e., Korgel does not teach “treating photoluminescent silicon nanoparticles under conditions effective to produce photoluminescent silicon nanoparticles having a Si-H terminated surface,” as required by claim 35.

Second, Korgel only teaches using a long list of capping agents *during* particle synthesis such that particle formation and capping occur simultaneously—it does not teach reacting any capping agents with hydrogen-terminated particles *after* particle formation, let alone doing so under conditions effective to achieve particle surface hydrosilylation. Swihart

Decl. ¶ 6. Thus, Korgel does not teach "treating ... Si-H surface-terminated nanoparticles under conditions effective to achieve particle surface hydrosilylation," as required by claim 35.

For these reasons, the anticipation rejection of claim 35 based on Korgel is improper and should be withdrawn.

The rejection of claim 34 under 35 U.S.C. § 103(a) for obviousness over Seraphin is respectfully traversed for substantially the reasons discussed above. Therefore, the obviousness rejection of this claim over Seraphin is improper and should be withdrawn.

In view of all of the foregoing, it is submitted that this case is in condition for allowance and such allowance is earnestly solicited.

Respectfully submitted,

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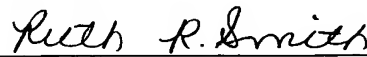
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